

A new species of *Cololejeunea* (Marchantiophyta, Lejeuneaceae) from New Zealand

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Abstract

A new epiphyllous species of *Cololejeunea* has been found in New Zealand lowland forests, currently known from only two localities, one each in the North and South Islands. It has been found on the leaves of four tree species, the fronds of two fern species, and on one liverwort growing in mixed epiphyllous communities with other liverworts and epiphyllous lichens. *Cololejeunea velutina* Glenny & M.A.M. Renner is distinctive in its combination of patent, elliptical leaves, high leaf papillae, the presence of a filiform stylus up to eight elongated cells long at the base of every lobule, and lobules with two teeth, the first of which is moniliform comprising two or three cells. In the field the species has a characteristic velvety appearance, by which it can readily be distinguished from other epiphyllous *Cololejeunea* in New Zealand.

Introduction

The genus *Cololejeunea* (Spruce) Steph. was proposed for a morphologically distinctive group of leafy liverworts, readily circumscribed by the incubous leaf insertion, the conduplicate bilobed leaves whose lobule insertion is constricted, the absence of underleaves, and the pendulous segmentation sequence, which results in a rhizoid bundle being produced in association with every lateral leaf. *Cololejeunea* has a cosmopolitan distribution, but the highest species diversity is encountered in the wet tropics.

Despite its morphological distinctness, which may in part be due to neoteny, *Cololejeunea* is rendered paraphyletic by *Chondriolejeunea* (Benedix) G. Kis & Pócs which nests within it in phylogenies inferred from molecular sequence data (Yu *et al.* 2013). Molecular evidence also suggests that the subgenera of *Cololejeunea* circumscribed by morphological data are polyphyletic, and not representative of natural historical units (Yu *et al.* 2013).

Cololejeunea is the largest genus in the Lejeuneaceae (He *et al.* 2012; Zhu *et al.* 2018). More than 400 species are currently accepted in *Cololejeunea* worldwide (Söderstrom *et al.* 2016), with most species occurring in the wet tropics. The flora of New Zealand contains 11 species, which is relatively depauperate in comparison to Australia (39), Fiji (44), and Papua New Guinea (63), but consistent with the lower diversity of tropical

lineages in southern temperate regions observed across the Lejeuneaceae (Pócs 2012, 2015, 2016; Pócs and Piippo 2011).

Despite having relatively low species diversity, the Lejeuneaceae flora of New Zealand is distinctive, comprising a suite of southern temperate species that may be New Zealand endemics; for example, species of *Nephelojeunea* Grolle and *Lejeunea* Lib. (Glenny 1996; Renner 2010; Renner *et al.* 2010).

Here we report the discovery of another morphologically distinct species that may also be a member of this southern temperate floristic group, a *Cololejeunea* found in lowland forests of both North and South Islands of New Zealand. *Cololejeunea velutina* Glenny & M.A.M. Renner has leaves without vitta, a long stylus of 5–8 uniseriate cells, and the dorsal surface of the main leaf lobe has a single papilla over each cell.

Other Australasian species that have leaf cell papillae and an absence of a vitta are *Cololejeunea mamillata* (Ångstr.) E.A. Hodgs. and *C. tenella* Benedix of Australia (Pócs 2016), and *C. hodgsoniae* (Herzog) E.A. Hodgs. of New Zealand (Hodgson 1967). Our plant does not match these Australasian species (Thiers 1988; Pócs 2015; Glenny 1996). None of these three species has a stylus.

Cololejeunea velutina also has similarities to four northern temperate, and two tropical *Cololejeunea* species which have a single papilla over each cell on the dorsal leaf surface and a filiform stylus. These are *C. nantashanensis* J.D. Yang & S.H. Lin of Taiwan, *C. biddlecomiae* (Austin) A. Evans and *C. ornata* A. Evans of North America, and *C. calcarea* (Libert) Schiffn. (Yang & Lin 2014). *Cololejeunea ornata* and *C. calcarea* are species of limestone rock and have an acute to acuminate leaf lobe apex (Schuster 1980; Smith 1990). *Cololejeunea nantashansis*, *C. biddlecomiae* and *C. ornata* have a stylus that can be 2–3 cells wide, usually at the stylus base, but sometimes midway along the stylus, while *C. calcarea* has a stylus that is uniseriate as in *C. velutina*. There are also two tropical species that have similarities to *C. velutina*: *C. filidens* Benedix of Malesia (Tixier, 1985) and *C. renneri* Pócs of Fiji (Pócs 2015). They share with *C. velutina* a papillate dorsal lobe surface and presence of a filiform stylus. Both species can be distinguished from *C. velutina* by their uniseriate, usually sharp, second lobule tooth, in contrast to the rounded to obtuse second lobule tooth of *C. velutina*. The stylus of *C. velutina* is 4–8 cells long while in *C. filidens* it is 3 cells long (Tixier, 1985) and it is 2–4 cells long in *C. renneri* (Pócs 2015). While *C. filidens* is said to be epiphylllic (Tixier, 1985), the type of *C. renneri* was collected from a dead fallen branch.

Taxonomy

Cololejeunea velutina Glenny & M.A.M. Renner *sp. nov.*

Type: New Zealand, North Island, Volcanic Plateau province, Pureora Forest, Rimu Track, 175.716993°E 38.565888°S, NZTM 1836720E, 5727895N, 460 m, *Dacrydium cupressinum* / *Beilschmiedia tawa* / *Coprosma tenuifolia* + *Dicksonia fibrosa* / *Leptopteris hymenophylloides* forest in floor of river valley, on leaves of *Beilschmiedia tawa*, with *Cololejeunea pulchella*, D. Glenny 14268 & M.A.M. Renner, 12 November 2018 (holotype: CHR 639909, isotypes: AK 372934, F, NSW).

Diagnosis: Similar in size and appearance to *Cololejeunea filidens* Benedix and *C. renneri* Pócs with a uniseriate stylus and a dorsal leaf surface with a papilla over each cell formed by a thickening of the outer cell wall. It differs from those two species in having a rounded to obtuse, rather than sharp, second lobule tooth and a stylus 4–8 cells long rather than 3 cells long as in *C. filidens* and 2–4 cells long as in *C. renneri*.

Etymology: The species epithet means velvety, in reference to the appearance of the plant in its fresh state, particularly when compared to *Cololejeunea pulchella*, a co-occurring species that is of similar size but very glossy.

Plants epiphylllic on leaf and fern frond surfaces, forming patches 9–17 mm diameter, closely attached, yellow-green and velvety in appearance when fresh, drying to yellow-brown. Shoots 0.95–1.0 mm wide. Branching exclusively lateral-intercalary, thecal or athecal, vegetative branches issuing at 90° to stem. Stem 60–50 µm diameter, 5 or 6 rows of cortical cells and 1 medulla cell row, cortical and medulla cells similar, 4 µm thick for both internal and outer walls. Rhizoids in clusters originating from a small area of the stem at the leaf base (Fig. 2), usually in clusters of 8 in 2 rows of 4. Leaves oblique to stem c. 45 degrees, imbricate and overlapping by the width of the lobule, dorsal stem completely covered by leaves; main lobe of leaf elliptical to slightly ovate, 520–580 µm long × 260–340 µm wide, apex rounded, margins entire except for projecting papillae. Cells of leaf lobe quadrate, 27–34 × 20–28 µm, trigones small and concave- to convex-sided, walls even in thickness but intermediate wall thickenings, sometimes weakly present, vitta absent but near-leaf-base cells as long as 28 µm; a single papilla present on the dorsal cell surface of all lobe cells except

the basal-most row, 4–8 μm high and 6–7 μm diameter, formed by a thickening of the cell wall, ventral cell surface plane. Oil-bodies (4)5–6(8) per cell, elliptical, $5.5\text{--}10.5 \times 3.7\text{--}4.0 \mu\text{m}$, moderately botryoidal, colourless. Lobule approximately $\frac{1}{4}$ the area of the lobe, elliptical, 220–260 μm long excluding the tooth, 150–160 μm wide, free margins positively curved but visible, keel positively curved at the base, the basisopic leaf margin straight from about mid-keel to the curve of the main lobe apex, lobule inner and outer surfaces not papillose, keel papillae 4 μm high; first lobule-tooth straight, 34–60 μm long, of 2–3 uniseriate cells, or 3 cells long and 2 cells wide at the base, the terminal cell 17–23 μm long and not elongated, the basal tooth attached to 2–4 cells of the lobule; hyaline papilla entally placed at the proximal base of the 1st lobule tooth, c. 10 μm high and 2 μm diameter; 2nd lobule tooth indistinct, separated from the 1st lobule tooth by 1–3 cells. Cells of the lobule similar in size to the main lobe cells, trigones medium-sized and convex, sometimes adjacent trigones partly fused, sometimes with a single intermediate wall thickening. Stylus of 4–8 uniseriate cells, 133–138 μm long, 14–25 μm wide, straight, submoniliform, attached 1 cell ventrally from the lobule keel base. Gemma initials sometimes present on ventral surface, unicellular, circular, 16–28 μm diameter, 3–19 per leaf, mature gemmae not seen.

Autoicous. Male branches 350 μm long, 1008 μm wide, on a short branch lacking normal leaves, or a long branch with normal leaves, or terminal on leading shoots, bearing up to 5 subislobous bracts, the largest 370 $\mu\text{m} \times 180 \mu\text{m}$, with a lobule of normal size, but main lobe reduced to only slightly larger than the lobule, the dorsal side of the bract papillose, the ventral side not papillose. Antheridia 40–70 μm diameter. Gynoecia on branches with normal leaves, a lateral-intercalary subfloral innovation continuing the branch beyond the gynoecium. Leaves below the gynoecium progressively modified into bracts. Final gynoecial bract below the perianth without a stylus, 500 μm long, 330 μm wide, unequally 2-lobed, the lobes loosely folded, the larger lobe with the free part 200–250 μm long, 180–240 μm wide, apex rounded, cells as for main leaf lobe or with intermediate wall thickenings, cells on both surfaces papillose, papillae up to 10 μm high; the smaller lobe with the free part 100–120 μm long, 145–160 μm wide, the apex untoothed but with a slime papilla at the summit, cells as for lobule, not papillose. Perianths obovoid, 530 μm long, 270 μm wide, unstalked, not flattened, 4-keeled: 2 larger lateral keels extending most of the length of the perianth, and 2 less pronounced ventral keels also extending most of the length of the perianth, the dorsal surface with a slight keel near the apex, rostrum not seen; cells of perianth surface more or less isodiametric, 13–18 μm diameter, papillae present on all outer cell walls, c. 6 μm high. Sporophyte not seen. Figs 1–4.

Distribution and ecology: *Cololejeunea velutina* is known from two localities in New Zealand: Pureora in the central North Island, and in the South Island at Pelorus Bridge Scenic Reserve, Marlborough Sounds. It was found on leaves of *Beilschmiedia tawa*, *Knightia excelsa*, *Coprosma grandifolia*, *Pseudopanax crassifolius*, on fronds of *Blechnum colensoi* and *Leptopteris hymenophylloides*, and on *Plagiochila trispicata* Colenso. At Pelorus Scenic Reserve it was found in two types of forest: tall podocarp forest of *Dacrycarpus dacrydioides* and *Prumnopitys spicata* with a high *Beilschmiedia tawa* understorey, and in *Nothofagus fusca* forest with young *tawa* plants forming a low understorey.

Similar species: *Cololejeunea velutina* is most similar to the New Zealand endemic species *C. falcidentata* R.M.Schust. in size, in having a papilla on each dorsal leaf cell surface as well as on the lobule keel, but not on the outer lobule surface, in lacking a vitta in the main leaf lobe, in having the lobule less than $\frac{1}{4}$ of the main lobe area, in having a first lobule tooth of 2–3 cells and a small 2nd lobule tooth, and in having circular gemmae. *Cololejeunea velutina* differs from *C. falcidentata* in being epiphyllic (*C. falcidentata* has been found on bark of *Podocarpus totara* and *Leptospermum scoparium*), in having a long stylus (stylus absent from *C. falcidentata*), in having the first lobule tooth straight (falcate in *C. falcidentata*), and in having trigones and sometimes intermediate wall thickenings (neither present in *C. falcidentata*).

Cololejeunea velutina also has some similarities to the Australian species *C. mamillata* (Ångstr.) E.A.Hodgs. in being epiphyllic, in having papillae on the outer main leaf lobe surface but not the lobule surface, in lacking a vitta in the main leaf lobe, in having the lobule about $\frac{1}{4}$ of the main lobe area, and in being autoicous. It differs in being larger, in having gemmae (absent from *C. mamillata*), in having a stylus (absent from *C. mamillata*), in having a larger first lobule tooth, and in having a rounded leaf apex (acute in *C. mamillata*).

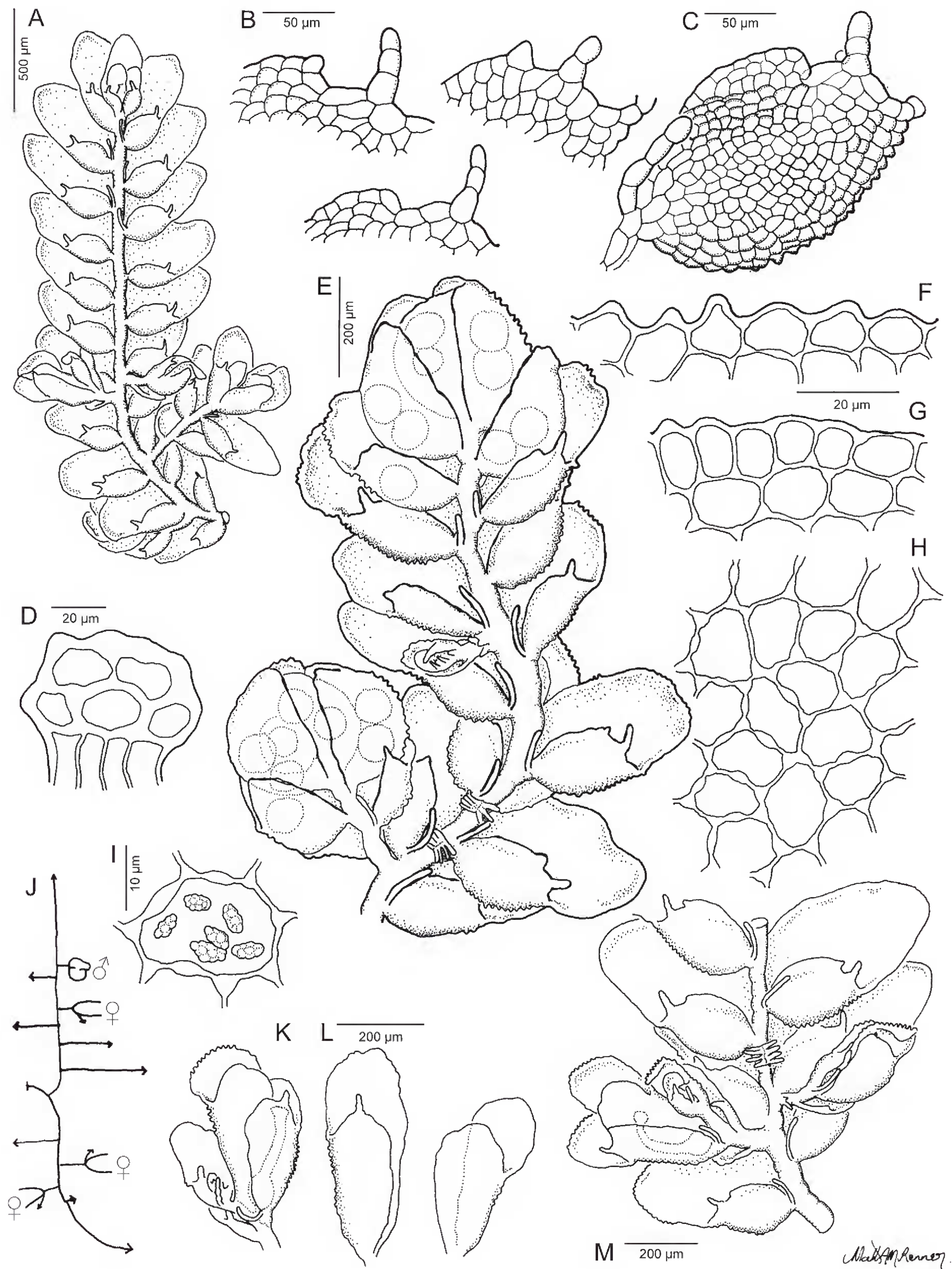


Fig. 1. *Cololejeunea velutina*. **A**: shoot sector in ventral view showing styli towards shoot apex, and gynoecia on short lateral branches; **B**: three lobule apices showing moniliform first lobule teeth and triangular second lobule teeth; **C**: whole lobule with basal stylus; **D**: stem transverse section showing single cortical cell row and transformation of two ventral cortical cell rows into rhizoids; **E**: section of male shoot showing terminal and lateral androecia; **F**: cells of leaf margin showing mamillae; **G**: cells of leaf margin showing variation in marginal shape; **H**: medial leaf-lobe cells; **I**: oil-bodies from medial leaf-lobe; **J**: cladogram showing position of gynoecia and androecia; **K**: gynoecial bracts *in situ*; **L**: gynoecial bracts separated; **M**: shoot section showing thecal and athecal branching. All from Glenny 14268 & Renner (AK).

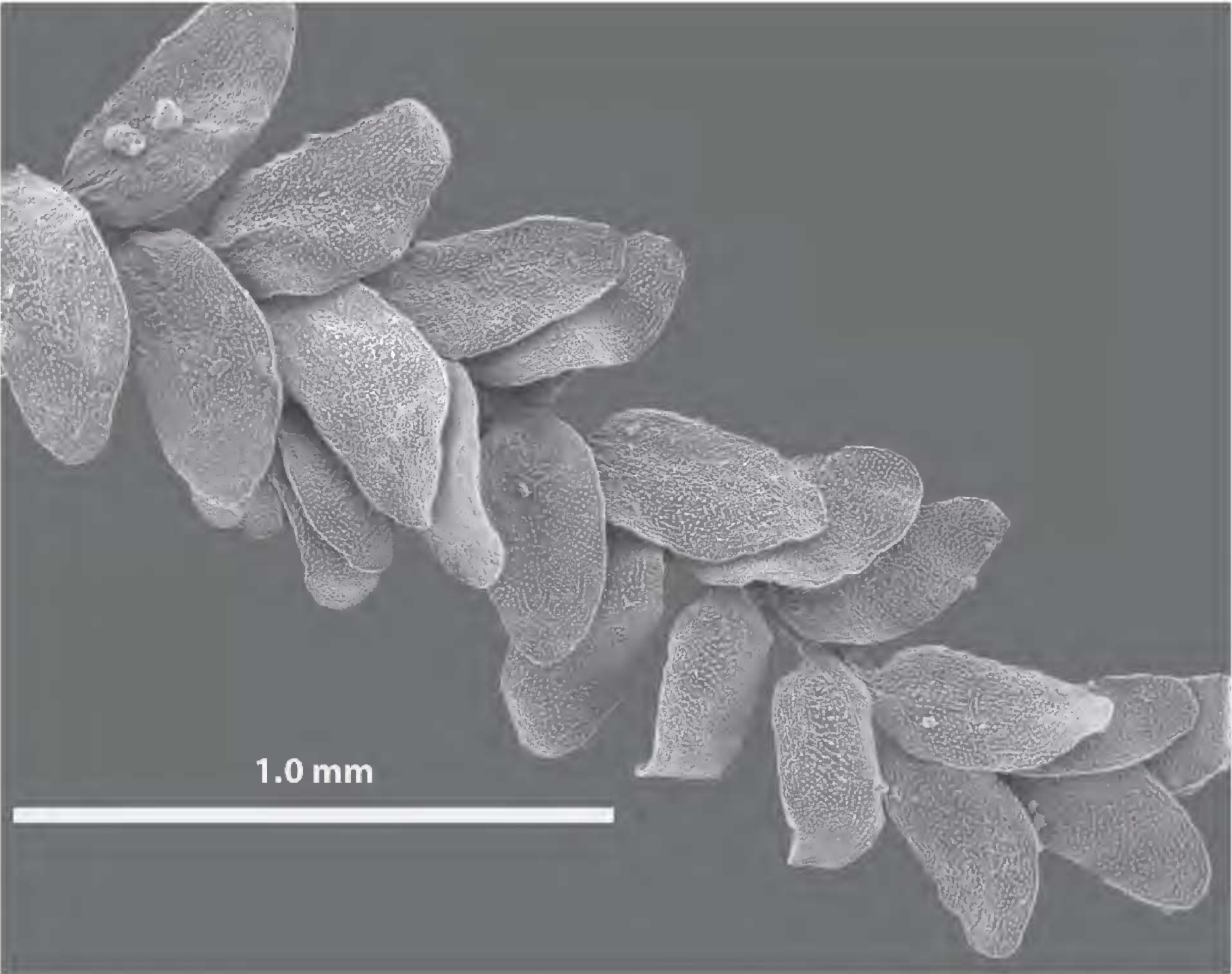


Fig. 2. *Cololejeunea velutina*. SEM photograph showing dorsal view of a single branch.

Characters distinguishing *C. velutina* from similar New Zealand species (those with papillate leaf lobes but no vitta) are summarised in Table 1.

Table 1. Similarities and differences between three New Zealand species, *Cololejeunea mamillata*, *C. falcidentata*, and *C. velutina*. Data on *C. mamillata* from Thiers (1988) and on *C. falcidentata* from Schuster (1968) and CHR 606746.

	<i>C. mamillata</i>	<i>C. falcidentata</i>	<i>C. velutina</i>
Sexuality	autoicous	autoicous	autoicous
Leaf length (µm)	150–300	300–370	520–580
Main lobe apex	acute	rounded	rounded
Gemmae	absent	present	present
Stylus	absent	absent	present, 5–8 cells long
1st lobule tooth	1–2-celled	2-celled	2–4-celled
Lobule keel	tuberculate in the distal half	tuberculate for the full length	tuberculate for the full length
Substrate	epiphyllous	epiphytic on bark	epiphyllous

Conservation status: *Cololejeunea velutina* is currently known from two localities, one in the central North Island, the other in the north of the South Island. At both sites *C. velutina* grew within forest: podocarp-broadleaf forest at Pureora and Pelorus Bridge, and southern beech forest at Pelorus Bridge. A qualitative assessment of habitats at both sites suggests the species is likely to be more widespread beyond these two localities, and should be searched for throughout New Zealand. Until such search effort better resolves where the species does and does not occur, the status Data Deficient under the Threatened Species Classification of Townsend *et al.* (2008) is appropriate. At Pureora *C. velutina* occurred at relatively low abundance in epiphyllous communities on several vascular plant species, but was detectable in both riparian and alluvial terrace forest communities. If *C. velutina* is confined to lowland forest with a tall podocarp component, it may be threatened as this habitat is very reduced in extent.

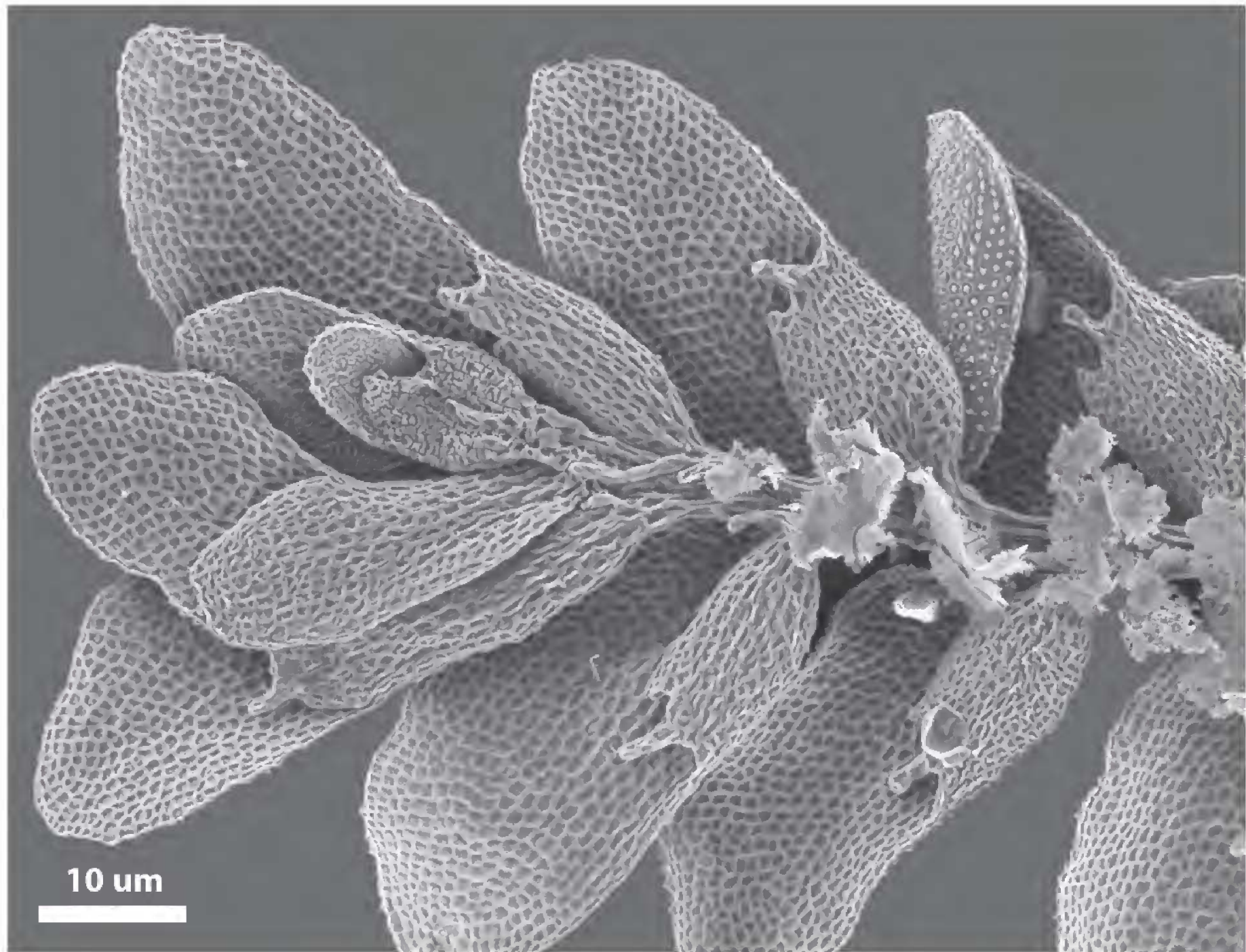


Fig. 3. *Cololejeunea velutina*. SEM photograph showing ventral view of apical part of a branch. The cuticle of the host leaf is attached to the rhizoids. A stylus with four elongated uniseriate cells is at image centre.

Other specimens examined: New Zealand, North Island, Volcanic Plateau province, Pureora Forest, Rimu Track, 175.716993°E 38.565888°S (NZTM 1836720E 5727895N), 460 m, *Dacrydium cupressinum* / *Beilschmiedia tawa* / *Coprosma tenuifolia* + *Dicksonia fibrosa* / *Leptopteris hymenophylloides* forest in floor of river valley, on fronds of *Leptopteris hymenophylloides*, D. Glenny 14267 & M.A.M. Renner, 12 November 2018 (CHR 639908); *Loc cit.*, on leaves of *Knightia excelsa*, D. Glenny 14269 & M.A.M. Renner, 12 November 2018 (CHR 639910); *Loc cit.*, on fronds of *Blechnum colensoi*, D. Glenny 14270 & M.A.M. Renner, 12 November 2018 (CHR 639911); *Loc cit.*, on leaves of *Coprosma grandifolia*, D. Glenny 14271 & M.A.M. Renner, 12 November 2018 (CHR 639912); *Loc cit.*, on leaves of *Pseudopanax crassifolius*, D. Glenny 14272 & M.A.M. Renner, 12 November 2018 (CHR 639913); New Zealand, South Island, Sounds-Nelson province, Pelorus Scenic Reserve, 173.569608°E 41.302952°S (NZTM 1647685E 5427455N), 40 m, *Dacrycarpus dacrydoides* and *Prumnopitys spicata* / *Beilschmiedia tawa* / *Cyathea dealbata* + *Dicksonia squarrosa* forest, on fronds of *Leptopteris hymenophylloides*, D. Glenny 14395a, 27 Dec 2018 (CHR 639915); Pelorus Scenic Reserve, 173.567717°E 41.305304°S (NZTM 1647525E 5427195N), 40 m, *Nothofagus fusca* forest, on leaves of *Beilschmiedia tawa* at 3 m above ground level near waterfall, with *Cololejeunea pulchella*, D. Glenny 14396, 27 Dec 2018 (CHR 639914); Pelorus Scenic Reserve, track between north end of highway bridge and suspension bridge over the Rai River, lowland mixed podocarp-beech forest with tawa and tree fern understorey, less than 100 ft, A.J.Fife 5760, 1 Oct 1983, (CHR 104332 pro parte, epiphyllous on *Plagiochila trispicata*).

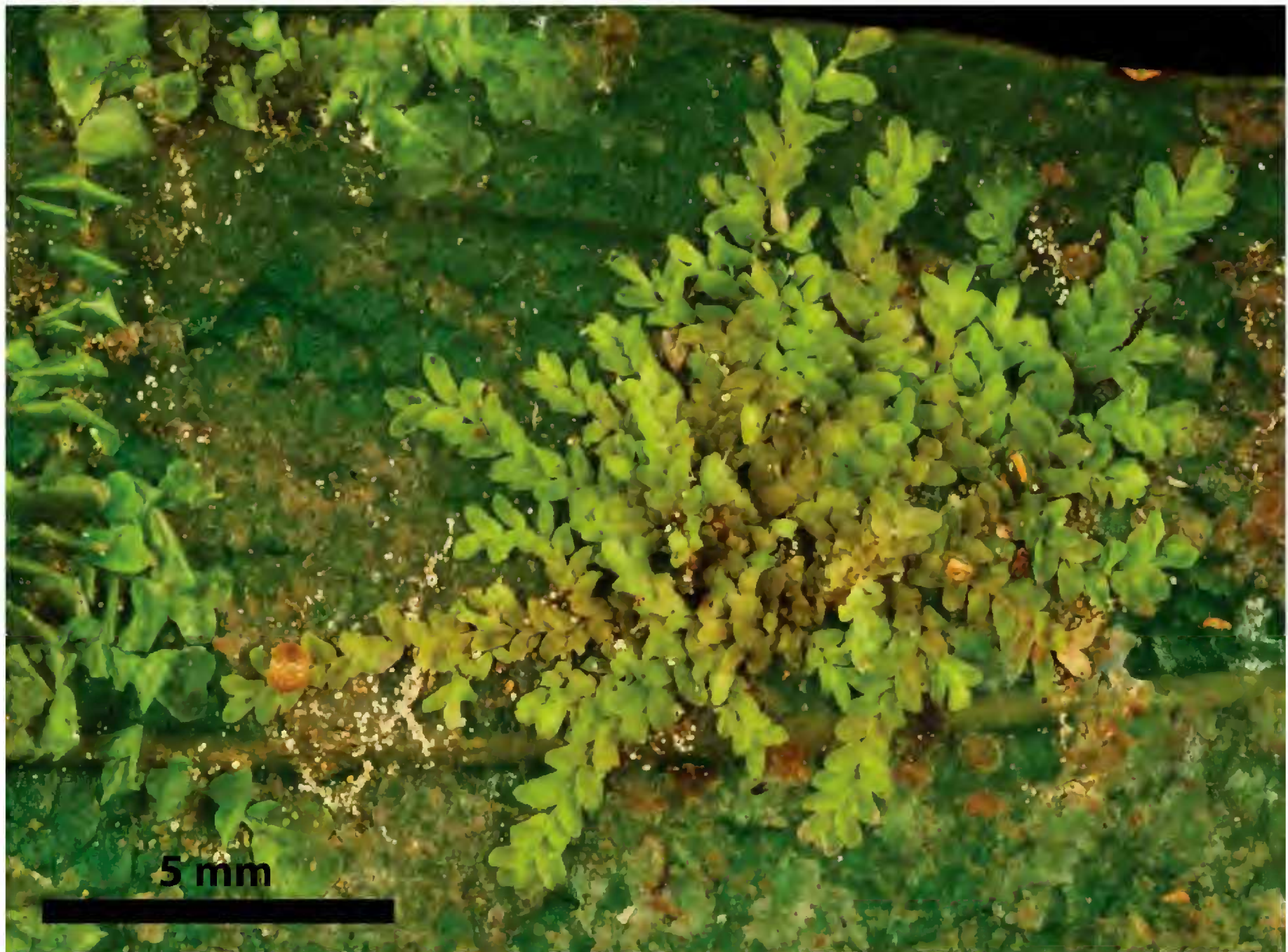


Fig. 4. Holotype of *Cololejeunea velutina*, on the upper surface of a leaf of *Beilschmiedia tawa*. *Cololejeunea pulchella* is growing on the same leaf to the left of the image. An epiphyllic lichen, *Strigula smaragdula* Fr.:Fr., is on the leaf margin at top right. The alga *Phycopeltis novae-zelandiae* R.H.Thompson & Wujek is also present on the leaf surface.



Fig. 5. *Cololejeunea velutina* growing on the upper leaf surface and leaf margin of *Pseudopanax crassifolius* at the type locality (from Glenny 14272 & Renner). The plant is 12 mm diameter.

Discussion

The type of *Cololejeunea velutina* was gathered from *Beilschmiedia tawa* leaves from several saplings at about 1–3 m above ground level, and all plants on tawa leaves are regarded as a single gathering. Plants were also collected at the type locality as epiphylls on other hosts: *Leptopteris hymenophylloides*, *Blechnum colensoi*, *Knightia excelsa*, *Coprosma grandifolia*, and *Pseudopanax crassifolius*. Collections from these other hosts are regarded as separate gatherings. All known specimens were growing on leaves or fern fronds, suggesting the species is an obligate epiphyll. It was not found on the bark of branches or on tree trunks at Pureora. None of the plants found had mature perianths, though older and partly eroded perianths were present on larger patches. Plants found on *Leptopteris hymenophylloides* and *Blechnum colensoi* fronds and on leaves of *Plagiochila trispicata* have not been found with perianths, and it appears that the best hosts are leaves of trees and shrubs in the low understorey. Fern fronds may not live long enough for the *Cololejeunea* to complete its life cycle on them.

The type locality was within c. 50 m of a river about 15 m wide, while at Pelorus Bridge Scenic Reserve the plants found on leaves of *Beilschmiedia tawa* were a few metres from a waterfall. It appears a very constantly humid atmosphere is required by *Cololejeunea velutina*. *Cololejeunea pulchella* is invariably present on the host leaves or fronds and is much more abundant than *C. velutina*. A search of herbarium specimens at CHR of *C. pulchella* to find more specimens of *C. velutina* was unsuccessful, and it appears that *C. velutina* may be uncommon.

There are few obligate epiphyllic liverworts in New Zealand, and most belong to the genus *Cololejeunea*. Six of the 11 species currently known in New Zealand (Gibb *et al.* 2017) are exclusively or nearly exclusively epiphyllic: *C. pulchella* (hosts *Beilschmiedia tawa*, *Hedycarya arborea*, *Pseudowintera colorata*, *Ascarina lucida*, *Podocarpus totara*, *Hymenophyllum villosum* or *H. sanguinolentum*), *C. laevigata* (Steph.) R.M.Schust. (hosts *Hymenophyllum demissum*, *Trichomanes reniforme*, *Blechnum novae-zelandiae* and *Pseudowintera colorata*), *C. floccosa* (Lehm. & Lindenb.) Schiffn. (host *Beilschmiedia taraira*), *C. appressa* (A.Evans) Benedix (host *Beilschmiedia taraira*), *C. hodgsoniae* (on leaves of several *Plagiochila* species, *Radula demissa*, and *R. marginata*), and *C. cucullifolia* (Herzog) E.A.Hodgs. (host *Laurelia novae-zelandiae*). *Cololejeunea velutina* joins this list of obligate epiphylls, and is known from hosts *Beilschmiedia tawa*, *Coprosma grandifolia*, *Knightia excelsa*, *Pseudopanax crassifolius*, *Blechnum colensoi* and *Leptopteris hymenophylloides*.

Two other two genera that have obligate epiphylls are the New Zealand endemic and monospecific *Echinolejeunea papillata* (Mitt.) Hamlin (hosts *Trichomanes reniforme*, *T. elongatum*, *Notogrammitis billardi*, *Hymenophyllum demissum*, *Blechnum colensoi*, *B. discolor*, and *Polystichum vestitum*) and the non-endemic *Leptolejeunea elliptica* (Lehm. & Lindenb.) Schiffn. (host mainly the leaves of *Freyinetia baueri*, but also *Leptopteris hymenophylloides* and *Ripogonum scandens*). In addition, there are two endemic obligate epiphyllic liverwort species on the leaves of the moss *Dendroligotrichum dendroides*: *Kymatolejeunea bartlettii* Grolle and *Nephelolejeunea papillosa* Glenny (Glenny 1996), which are highly adapted to their unusual, large-dendroid moss host and have not been found on other hosts.

The elevational range of these obligate epiphylls is (in order of mean elevation from lowest to highest):

Leptolejeunea elliptica 50–60 m (mean 55 m), *Cololejeunea appressa* 80 m, *C. hodgsoniae* 20–330 m (mean 230 m), *C. pulchella* 5–460 m (mean 197 m), *C. velutina* 40–460 m (mean 250 m), *Echinolejeunea papillata* 100–390 m (mean 260 m), *C. laevigata* 50–890 m (mean 350 m), *C. cucullifolia* 80–915 m (mean 460 m), *Kymatolejeunea bartlettii* 620–1190 m (mean 920 m), and *Nephelolejeunea papillosa* 490–1300 m (mean 976 m).

In addition, in New Zealand there are 13 facultatively epiphyllic liverwort species, which occur on twigs, branches, and tree trunks but complete their life cycle as epiphylls: *Austrolejeunea olgae* (R.M.Schust.) R.M.Schust., *Cololejeunea ellipsoidea* R.M.Schust., *C. grossepapillosa* (Horik.) N.Kitag., *Colura saccophylla* E.A.Hodgs. & Herzog, *Drepanolejeunea ternatensis* (Gottsche) Steph., *Frullania aterrima* (Hook.f. & Taylor) Hook.f. & Taylor, *F. pycnantha* (Hook.f. & Taylor) Taylor, *F. rostrata* (Hook.f. & Taylor) Hook.f. & Taylor (von Konrat and Braggins 1999), *Lejeunea colensoana* (Steph.) M.A.M.Renner, *L. epiphylla* Colenso, *L. helmsiana* Steph., *L. primordialis* Gottsche, Lindenb. & Nees, *L. tumida* Mitt., *Microlejeunea latitans* (Hook.f. & Taylor) Heinrichs, Schäf.-Verw., Pócs & S.S.Dong, *Radula demissa* M.A.M.Renner, and *Siphonolejeunea nudipes* (Hook.f. & Taylor) Herzog. Von Konrat and Braggins (1999) note that the leaves of *Beilschmiedia tawa*, *Podocarpus laetus* (as *P. hallii*), *Pseudowintera colorata*, and the cladodes of *Phyllocladus trichomanoides* are hosts of epiphyllic *Frullania* species.

There are also liverworts that can occasionally be found as epiphylls and many of these may not complete their life cycle on their leafy host: *Cheilolejeunea campbelliensis* (Steph.) R.M.Schust., *Chiloscyphus muricatus* (Lehm.) J.J.Engel & R.M.Schust., *Frullania chevalieri* (R.M.Schust.) R.M.Schust., *F. deplanata* (Mitt.), *F. fugax* (Hook. f. & Taylor) Gottsche, Lindenb. & Nees, *F. hodgsoniae* von Konrat, Braggins, Hentschel & Heinrichs,

F. nicholsonii E.A.Hodgs., *F. patula* Mitt., *F. ptychantha* Mont., *F. pycnantha* (Hook.f. & Taylor) Gottsche, Lindenb. & Nees, *F. scandens* Mont. (von Konrat and Braggins 1999), *Lepidolaena palpebrifolia* (Hook.) Trevis., *Lepidozia digitata* Herzog, *Metzgeria furcata* (L.) Corda, *Austrolejeunea hispida* R.M.Schust., *Psiloclada clandestina* Mitt., *Radula ratkowskiana* K.Yamada, *R. strangulata* Hook.f. & Taylor, *R. tasmanica* Steph., and *Telaranea granulata* J.J.Engel & G.L.Merr.

For comparison New Zealand has about 76 lichen epiphylls (Malcolm and Malcolm 2016). Most of these are obligate epiphylls of tree leaves or fern fronds. New Zealand appears to have no obligate epiphyllic mosses, but a number of mosses commonly grow on tree leaves and fern fronds in cool, humid forest sites, but they probably rarely complete their life cycle there.

Key to papillose *Cololejeunea* species of New Zealand

(modified from Renner and Pócs 2011)

- 1a Leaves with vitta 2
- 1b Leaves without vitta 3
- 2a First lobule tooth of two or three cells, strongly falcate, apex often extending backwards beyond the basiscopic lobe margin, second lobule tooth indistinct..... *Cololejeunea floccosa*
- 2b First lobule unicellular or of two cells, straight, second lobule tooth distinct, the two teeth forming an obvious notch within which the lobule papilla is situated *Cololejeunea appressa*
- 3a Filiform stylus produced at the junction of each lobule and the stem, (3)4–5(8) cells long; the stylus may dislocate as shoots mature, but they are reliably present near the apex of every shoot at the base of every lobule..... *Cololejeunea velutina*
- 3b Stylus absent..... 4
- 4a Vegetative branching athecal. Leaves subislobous, lobules four-fifths the size of the lobe, first lobule tooth two-celled, lobule papilla attached to lobule margin between first and second teeth. Gemmae copious, 16-celled *Cololejeunea grossepapillosa*
- 4b Vegetative branching thecal. Leaves anislobous, lobules half or less the size of the lobe, first lobule tooth unicellular or of two cells, lobule papilla attached inner surface of lobule behind first tooth. Gemmae present or absent 5
- 5a Lobule without prominent lobule teeth, first lobule tooth obscure, lobule margins serrate due to papillose marginal cells, lobule papillose over entire surface, including keel and surface of carinal region *Cololejeunea hodgsoniae*
- 5b Lobule with first lobule tooth prominent, two-celled, lobule margins entire, lobule papillose on keel only 6
- 6a First lobule tooth usually falcate *Cololejeunea falcidentata*
- 6b First lobule tooth straight..... *Cololejeunea mamillata*

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